ENERGY CODES 2010

Residential HVAC Design

Load Calculation- <u>ACCA Manual J</u> (8^{th} Edition)

WHY DESIGN??

- Oversized equipment degrades humidity control
- Oversized equipment requires larger ducts
- Oversized equipment has a higher up front cost
- Under-sizing equipment can cause discomfort during severe weather
- Oversized equipment causes short cycling and reduces the air conditioning systems ability to remove moisture
- Equipment that is sized properly operates more efficiently and economically
- Increased duct system efficiency
- Demonstrate "due diligence" in a court of law
- Equipment size typically 30-50% smaller than systems designed by "rule of thumb"
- Reduce operating cost

2009 IRC

M1401.3 Sizing. Heating and cooling *equipment* shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.

M1601.1 Duct design. Duct systems serving heating, cooling and ventilation equipment shall be fabricated in accordance with the provisions of this section and ACCA Manual D or other approved methods.

M1601.3.1 Joints and seams. Joints of **duct systems shall be made substantially airtight** by means of tapes, mastics, gasketing or other approved closure systems. Closure systems used with rigid fibrous glass ducts shall comply with UL 181A and shall be marked “181A-P” for pressure-sensitive tape, “181A-M” for mastic or “181A-H” for heat-sensitive tape. Closure systems used with flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic. Duct connections to flanges of air distribution system equipment or sheet metal fittings shall be mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked 181B-C. Crimp joints for round metal ducts shall have a contact lap of at least 1.5 inches (38 mm) and shall be mechanically fastened by means of at least three sheet metal screws or rivets equally spaced around the joint. Closure systems used to seal metal ductwork shall be installed in accordance with the manufacturer’s installation instructions.

N1103.2.2 Sealing.
Ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.4. Duct tightness shall be verified by either fo the following:

1.Post-construction test: Leakage to outdoors shall be less than or equal to 8 cfm (3.78 L/s) per 100 ft2 (9.29 m2) of conditioned floor area or a total leakage less than or equal to 12 cfm (5.66 L/s) per 100 ft2 (9.29 m2) of conditioned floor area when tested at a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler end closure. All register boots shall be taped or otherwise sealed during the test.

2.Rough-in test: Total leakage shall be less than or equal to 6 cfm (2.83 L/s) per 100 ft2 (9.29 m2) of conditioned floor area when tested at a pressure differential of 0.1 inch w.g. (25 Pa) across the roughed in system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 4 cfm (1.89 L/s) per 100 ft2 (9.29 m2) of conditioned floor area.

Exception: Duct tightness test is not required if the air handler and all ducts are located within conditioned space.

A reasonably well accepted definition of ‘substantially airtight ductwork’

‘If ductwork is located inside the buildings thermal envelope the ductwork shall not leak more than 10% of design airflow’

‘If ductwork is located outside the buildings thermal envelope the ductwork shall not leak more than 5% of design airflow’

The Residential HVAC Design Process:

1. Load Calculation- ACCA Manual J (8th Edition)

The entire design process leads to and rests upon the room to room load calculations. It is the Manual J that calculates the homes heating and cooling needs. (Does the 'Code' require cooling?) This includes each separate room's thermal requirements. You do want each room to be comfortable, don't you??

There are many times when more than one HVAC system is required to meet a homes heating and cooling needs. A zoning plan would then need to be developed. **ACCA Manual RS** provides in-depth information on zoning and system selection. Zoning and system selection **MUST** be part of the homes design process.

2. Equipment Selection- ACCA Manual S

Now that the load calculation is done, proper sized equipment can be selected. Equipment selection has its own set of rules. Learning how to read and interpret the manufactures equipment performance data including the fine print. The goal here is to select equipment that will:

1. Meet the homes calculated heating and cooling needs under design conditions.
2. Will have enough blower power to move the correct amount of air through the duct system.

3. Duct Design – ACCA Manual D

In residential systems, the duct system is designed to match the equipments blower capabilities. Not the other way around!! Careful attention must be paid to duct length and type of fittings used. Proper attention to duct design will insure that the needed amount of conditioned air is delivered to each room.

4. Room Air Distribution – ACCA Manual T

Selecting the proper sized grilles and registers has its own set of requirements. You could have a properly sized system, perfect equipment, an outstanding duct system and ruin everything with the incorrect grilles and registers.

WHAT IS NEEDED FOR AN ACCURATE LOAD CALCULATION?

- Use outdoor design Conditions from MJ8 Table 1A

  These values are not the worst weather conditions ever experienced in a city; but they do represent extremes that on the average will only be exceeded a few dozen hours per season. Local code requirement may supercede theses values.

1% Summer Outdoor Drybulb, The outdoor temperature that will only be exceeded for 1% of the hours of a standard weather year, as defined by the bin hour data for that location.

99% Winter Outdoor Drybulb, The outdoor temperature that will be equal to or less than 99% of the hourly outdoor temperature that will occur during a standard weather year, as defined by the bin hour data for that location.

Table 1A

Outdoor Design Conditions for the United States

Location	Elevation	Latitude	Winter	Summer					
	Feet	Degrees North	Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincident Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Colorado									
Alamosa AP	7543	37	-11	82	55	-53	-46	-40	H
Boulder	5385	40	0	91	59	-47	-40	-34	H
Colarado Springs AP	6171	38	4	87	58	-46	-39	-33	H
Craig	6283	40	-12	85	56	-52	-45	-39	H
Denver AP	5283	39	-3	90	59	-46	-39	-33	H

Coincident Wet Bulb represents the average wet-bulb temperature expected to co-exist with the 1% dry-bulb temperature

WHAT IS NEEDED FOR AN ACCURATE LOAD CALCULATION?

- Indoor design conditions

  Winter 70° Dry Bulb at a RH that will not produce visible condensation this is typically not more than 30%.

  Summer 75° Dry Bulb at 50% RH
  This is psychometrically equivalent to 62° wet bulb. This will be important when we size the cooling equipment.

- Infiltration Estimates
  Full credit should be taken for the type of construction used. This could be from blower door tests or builders track record. MJ8 has five construction quality types Tight, Semi-Tight, Average, Semi-Loose and Loose.

	ACH Heating	Cooling
Tight ----------	.10	.05
Semi-Tight --	.19	.10
Average ------	.28	.15
Semi-Loose --	.43	.23
Loose ---------	.58	.30

  Typically builders will use 'Average' construction. See Manual J Table 5A.

- Solar Loads Associated with Glass
  In MJ8 solar gains are ignored in the heating calculation. This produces a conservative estimate of the load associated with an extended period of heavy day time cloud cover. In the case of the MJ8 cooling load, the tabulated data provides an estimate of the combined load (solar and conductance) associated with the glass, by direction of exposure. Be sure and take credit for drapes, insect screens, blinds, external screens and overhangs.

- Duct losses and Gains
  Where and how ducts are installed can have a large impact on the required loads. Ducts installed in an attic can add a ton or more to the air conditioning load. Leaky ductwork can range from 30% to more than 45% of the blower CFM.

WHAT IS NEEDED FOR AN ACCURATE LOAD CALCULATION?

- Conduction Loads

  The structural component conduction loads caused by the design conditions can be reasonably calculated. The designer should take full credit for all construction details. R-values, mass walls, etc.

- Ventilation Loads

  Some builders may choose to bring in ventilation air or may be required by the local code. How the ventilation air is introduced into the system will determine the effect on heating or air conditioning loads. Is the air brought directly into the return air trunk line or through a heat-recovery devise?

- Internal loads

  MJ8 provides some generic values for internal loads created by people and appliances.
  Defaults for MJ8:
  Appliances – 1500 Btuh per appliance
  People – 230 Btuh Sensible, 200 Btuh Latent, 20 cfm of ventilation air per person

Load Calculation- ACCA Manual J (8th Edition)

There are four accredited ACCA Manual J 8th Edition software programs

- Elite RHVAC
- Wrightsoft Right-J8
- Nitek HVAC Wizard
- Adtek AccuLoads

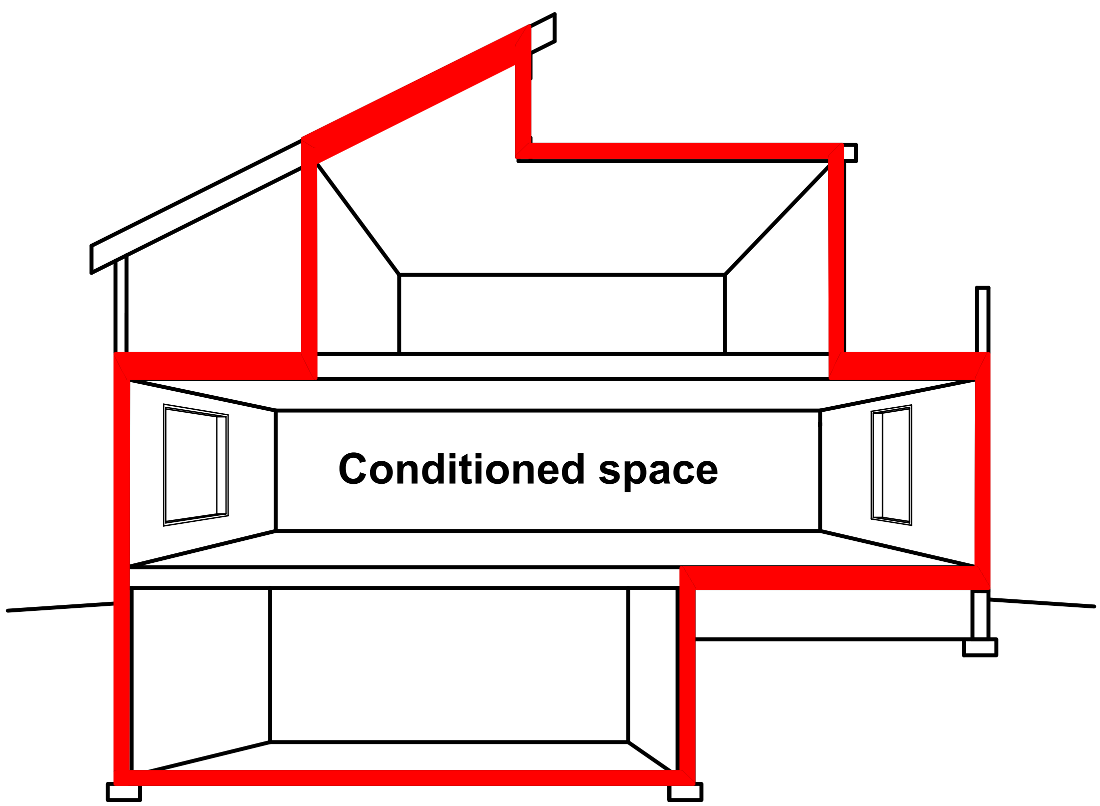
Manual J-AE (Abridged Edition) has limitations:

1. The structure is a single family detached dwelling; the total window, glass door and skylight area does not exceed 15% of the associated floor area.
2. The glass is equitably distributed around all sides of the dwelling – the dwelling appears to have obvious and sufficient exposure diversity.
3. Heating and cooling is provided by a central, single zone, constant volume system.
4. The comfort system is not equipped with a ventilation heat exchanger or a ventilating dehumidifier.

These are the first four of twenty-six different requirements that must be answered with a 'Yes' to confirm that MJ-AE is the appropriate calculation tool. MJ-AE is very good for learning the basic requirements for residential load calculation.

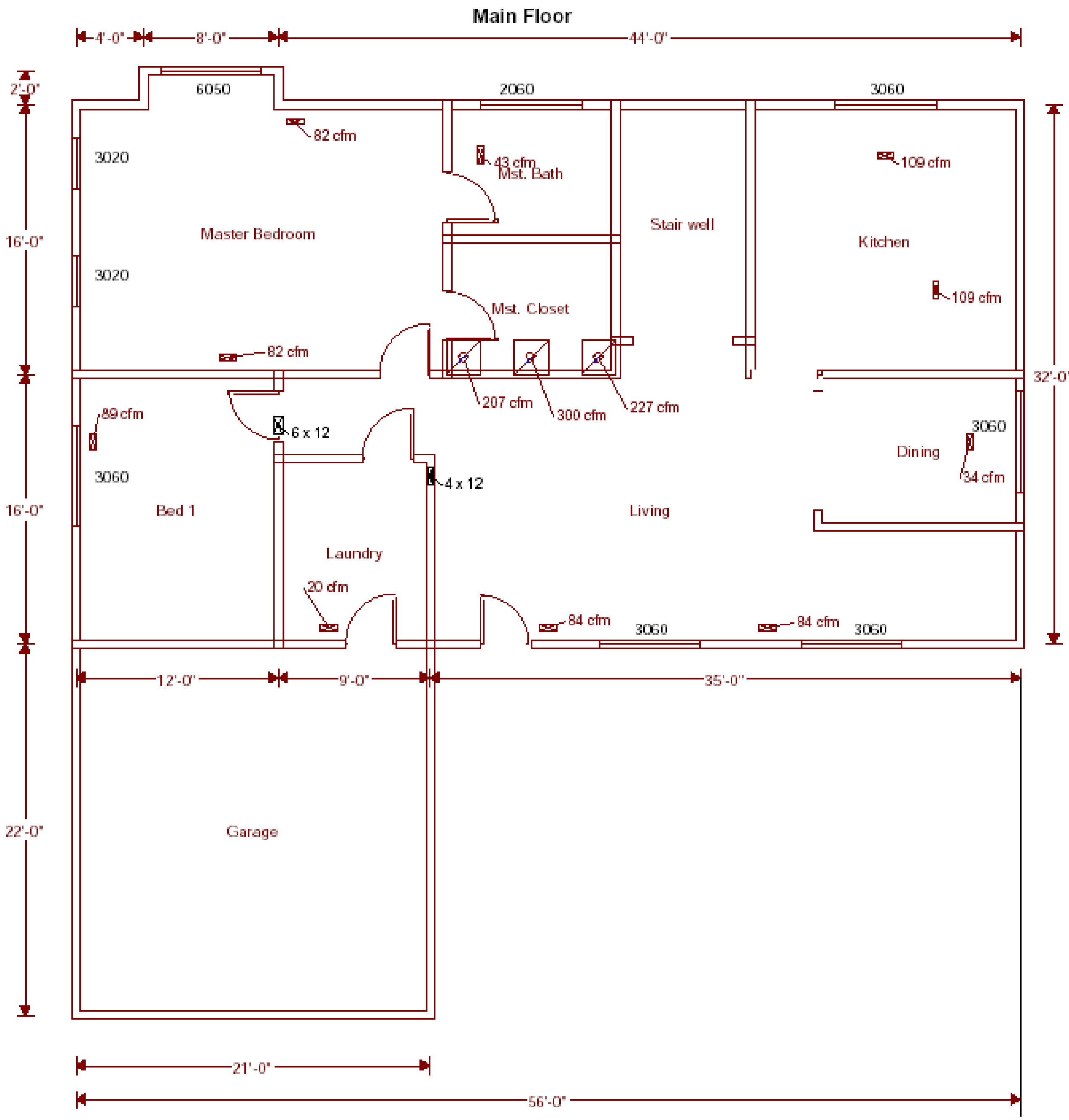
DEFINE YOUR THERMAL BARRIER

- Building thermal barrier consists of:
    - Fenestration
    - Ceilings
    - Walls
        - Above grade
        - Below grade
        - Mass walls
    - Floors
    - Slab
    - Crawl space



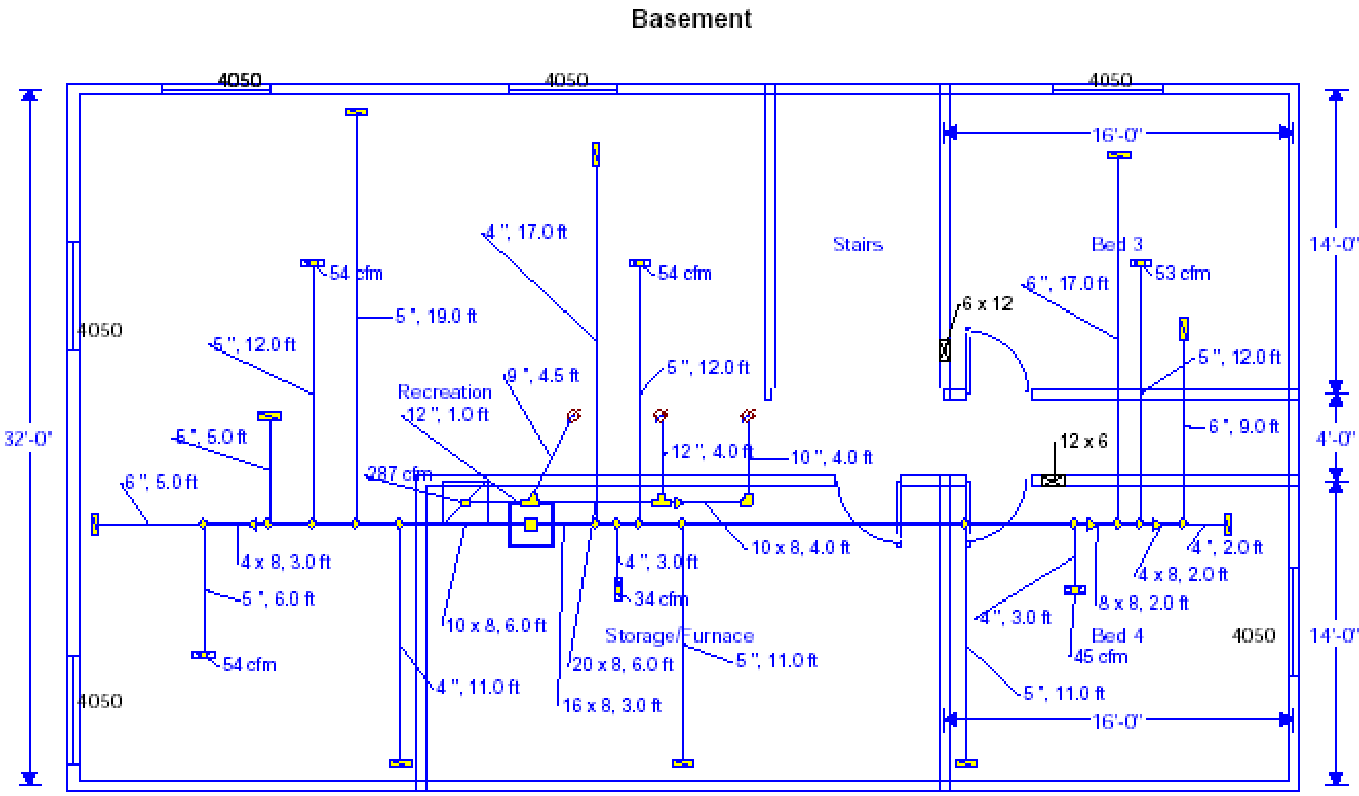
Today's House

Denver   Climate Zone 5B   Prescriptive Path



R-19 Exterior Walls
R-38 Ceilings
R-30 Floors
Windows   U-Value = .34   SHGC = .40

Today’s House



Weather Data from Table 1A

1% Summer Outdoor Drybulb = 90° F

99% Winter Outdoor Drybulb = 3° F

Elevation = 5333’

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Daily Range is the average difference between the daily high and low dry bulb temperatures at a particular location.
Low (L) = swing less than 16° F
Medium (M) = swing between 16° F and 25° F
High (H) = swing exceeds 25° F

Moisture Difference is the absolute humidity differential between the outdoor air and the indoor air, expressed in grains of water per pound of air.

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
GAMA ID	144278

Efficiency	92.1 AFUE	
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Make	Carrier
Trade	Base 13 Puron AC
Cond	24ABA324A30
Coil	CAP**2414A**++TDR
ARI ref no.	738723

Efficiency	11.6 EER, 13 SEER	
Sensible cooling	18148	Btuh
Latent cooling	3203	Btuh
Total cooling	21350	Btuh
Actual air flow	995	cfm
Air flow factor	0.063	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

Printout certified by ACCA to meet all requirements of Manual J 8th Ed.

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Weather: Denver, CO, US

Winter Design Conditions

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Heating Summary

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Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Ducts with no load would be located entirely inside the buildings thermal barrier.
Central vent is the result of infiltration and ventilation air.

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
GAMA ID	144278

Efficiency	92.1 AFUE	
Heating input	40000	Btuh
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Cooling Equipment Summary

Make	Carrier
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Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Volume is the above grade volume

Air changes /hour for heating is done with a 15 mph wind and 7.5 mph for cooling

AVF = Air Volume Flow

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
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Use manufacturer's data	y	
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Notes:

Design Inf

Weather: Denver, C

Sensible Load
The heat gain of the home due to conduction, solar radiation, infiltration, appliances, people and pets. Burning a light bulb, for example, adds only sensible load to the house. The sensible load raises the dry-bulb

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Heating Equipment Summary

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Static pressure	0.70	in H2O
Space thermostat		

Sensible Cooling Equipment Load Sizing

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Blower	0	Btuh
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Latent Cooling Equipment Load Sizing

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Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Latent Cooling Load
The net amount of moisture added to the inside air by people, plants, cooking, infiltration and any other moisture source.
SHR = Sensible Heat Ratio
The ratio of sensible load to total load

Example House
16,613/16,613 = 1.00

So why are we using .85 ???

Cooling Equipment Summary

Make	Carrier	
Trade	Base 13 Puron AC	
Cond	24ABA324A30	
Coil	CAP**2414A**++TDR	
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Efficiency	11.6 EER, 13 SEER	
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Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

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Sensible Heat Equation to calculate a preliminary cooling CFM

CFM = Sensible Load ÷ (1.1 x ACF x ΔT)

Where:
Sensible Load (Btuh) is the sensible cooling load from the MJ8 load calculation.
CFM (cubic feet per minute) is the volume of the air moving through the furnace and the indoor cooling coil.
1.1 is a physical constant for the equation.
ACF (altitude correction factor) is the adjustment for air density at the local altitude.
ΔT is the temperature difference in the air between the inlet and the outlet furnace/cooling coil.
We will use the table from Manual S.

Sensible Heat Ratio vs. Cooling Coil Temperature Difference (ΔT)	
JSHR	ΔT
Below 0.80	21° F
0.80 – 0.85	19° F
Above 0.85	17° F
ΔT = Entering Dry Bulb – Leaving Dry Bulb	

A high SHR will have a low or negative latent load (like Denver at elevation)
A low SHR will have a large latent load (like Florida)

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Entire House
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By: Gil Rossmiller

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For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	**Cooling**
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Sensible Cooling Equipment Load Sizing

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Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
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Latent Cooling Equipment Load Sizing

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Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Heating Equipment Summary

Make	Carrier
Trade	Carrier
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Static pressure	0.70	in H2O
Space thermostat		

Cooling Equipment Summary

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Coil	CAP**2414A**++TDR
ARI ref no.	738723

Efficiency	11.6 EER, 13 SEER	
Sensible cooling	18148	Btuh
Latent cooling	3203	Btuh
Total cooling	21350	Btuh
Actual air flow	995	cfm
Air flow factor	0.063	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

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Component Constructions

Entire House

Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Design Conditions

Location:
Denver, CO, US
Elevation: 5331 ft
Latitude: 40°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	3	90
Daily range (°F)	-	27 (H)
Wet bulb (°F)	-	59
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	67	15
Relative humidity (%)	50	50
Moisture difference (gr/lb)	60.6	-35.9

Infiltration:

Method	Simplified
Construction quality	Average
Fireplaces	0

Construction descriptions	Or	Area ft²	U-value Btuh/ft²-°F	Insul R ft²-°F/Btuh	Htg HTM Btuh/ft²	Loss Btuh	Clg HTM Btuh/ft²	Gain Btuh
Walls								
12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm							0.96	244
							0.96	215
							0.96	233
							0.96	373
							0.96	1065
15B13-0wc-8: Bg wall, light dry soil, 2"x4" wood int frm, concrete wall, r-13 cav ins, 8" thk, 1/2' gypsum board int fnsh	ne	236	0.049	13.0	3.03	716	0	0
	se	448	0.049	13.0	3.28	1471	0	0
	sw	216	0.049	13.0	2.74	591	0	0
							0	0
							0	0
Partitions								
12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm							02	248
Windows								
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (3 ft window ht, 2 ft sep.)	ne	18	0.340	0	22.8	410	21.7	391
	se	36	0.340	0	22.8	820	23.7	853
	sw	18	0.340	0	22.8	410	23.7	427
	nw	18	0.340	0	22.8	410	21.7	391
	all	90	0.340	0	22.8	2050	22.9	2062
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen	ne	20	0.340	0	22.8	456	21.7	434
	sw	40	0.340	0	22.8	911	26.6	1063
	nw	60	0.340	0	22.8	1367	21.7	1302
							23.3	2799
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (2 ft window ht, 2 ft sep.)							22.3	267
							21.7	260
							22.0	528
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (5 ft window ht, 2 ft sep.)							21.7	651
Doors								
11N0: Door, mtl eps core type	se	21	0.350	8.7	23.4	492	8.14	171

There are hundreds of construction discriptions. They should match the construction plans.

A Partition is a wall that seperates a conditioned area from a unconditioned area. This would be typical of a wall between the house and the garage.

Verify that the designer has taken credit for blinds, screens and overhangs.

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Component Constructions
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Design Conditions

Location:		
Denver, CO, US		
Elevation:	5331 ft	
Latitude:	40°N	
Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	3	90
Daily range (°F)	-	27 (H)
Wet bulb (°F)	-	59
Wind speed (mph)	15.0	7.5

Indoor:	Heating	Cooling
Indoor temperature (°F)	70	75
Design TD (°F)	67	15
Relative humidity (%)	50	50
Moisture difference (gr/lb)	60.6	-35.9
Infiltration:		
Method	Simplified	
Construction quality	Average	
Fireplaces	0	

Construction descriptions

Construction descriptions	Or	Area ft²	U-value Btuh/ft²-°F	Insul R ft²-°F/Btuh	Htg HTM Btuh/ft²	Loss Btuh	Clg HTM Btuh/ft²	Gain Btuh
Walls								
12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm	ne	254	0.068	19.0	4.56	1157	0.96	244
	se	223	0.068	19.0	4.56	1016	0.96	215
	sw	242	0.068	19.0	4.56	1103	0.96	233
	nw	388	0.068	19.0	4.56	1768	0.96	373
	all	1107	0.068	19.0	4.56	5043	0.96	1065
	ne	236	0.049	13.0	3.03	716	0	0
	se	448	0.049	13.0	3.28	1471	0	0
	sw	216	0.049	13.0	2.74	591	0	0
	nw	388	0.049	13.0	2.83	1097	0	0
	all	1288	0.049	13.0	3.01	3875	0	0
Partitions								
12E-0sw: Frm wall, wd ext, 1/2" wood shth, r-19 cav ins, 1/2" gypsum board int fnsh, 2"x6" wood frm								
Windows								
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (3 ft window ht, 2 ft sep.)	ne	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	se	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	sw	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	nw	18	0.340	0	22.8	410	21.7	391
	all	90	0.340	0	22.8	2050	22.9	2062
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen	ne	20	0.340	0	22.8	456	21.7	434
	sw	40	0.340	0	22.8	911	26.6	1063
	nw	60	0.340	0	22.8	1367	21.7	1302
	all	120	0.340	0	22.8	2734	23.3	2799
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (2 ft window ht, 2 ft sep.)	sw	12	0.340	0	22.8	273	22.3	267
	nw	12	0.340	0	22.8	273	21.7	260
	all	24	0.340	0	22.8	547	22.0	528
VINYL U 34 SHGC 40: Vinyl Clad Low-E Window; NFRC rated (SHGC=0.40); 50% blinds 45°, medium; 50% outdoor insect screen; 2 ft overhang (5 ft window ht, 2 ft sep.)	nw	30	0.340	0	22.8	683	21.7	651
Doors								
11N0: Door, mtl eps core type	se	21	0.350	8.7	23.4	492	8.14	171

In Wrightsoft there is a command to turn the house in the direction with the highest loads. It is not unusual for production builders to do this.

HTM = Heat Transfer Modifier
All of the Manual J formulas boil down to an HTM. The HTM times the area equals the heat loss or gain.

wrightsoft

Right-J® Worksheet
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

1	Room name				Entire House						Living				
2	Exposed wall				400.0 ft						42.0 ft				
3	Ceiling height				8.0 ft						8.0 ft		heat/cool		
4	Room dimensions										1.0 x 513.0 ft				
5	Room area				4062.0 ft²						513.0 ft²				

	Ty	Construction number	U-value (Btuh/ft²-°F)	Or	HTM (Btuh/ft²) Heat	HTM (Btuh/ft²) Cool	Area (ft²) or perimeter (ft) Gross	Area (ft²) or perimeter (ft) N/P/S	Load (Btuh) Heat	Load (Btuh) Cool	Area (ft²) or perimeter (ft) Gross	Area (ft²) or perimeter (ft) N/P/S	Load (Btuh) Heat	Load (Btuh) Cool
6	W	12E-0sw	0.068	ne	4.56	0.96	272	254	1157	244	56	56	255	54
.	G	VINYL U 34 SHGC	0.340	ne	22.78	21.70	18	0	410	391	0	0	0	0
.	W	15B13-0wc-8	0.093	ne	3.03	0.00	256	236	716	0	0	0	0	0
.	G	VINYL U 34 SHGC	0.340	ne	22.78	21.70	20	0	456	434	0	0	0	0
11	W	12E-0sw	0.068	se	4.56	0.96	280	223	1016	215	280	223	1016	215
	G	VINYL U 34 SHGC	0.340	se	22.78	23.71	36	6	820	853	36	6	820	853
	D	11A0	0.350	se	23.45	8.14	21	21	492	171	21	21	492	171
	W	15B13-0wc-8	0.093	se	3.28	0.00	448	448	1471	0	0	0	0	0
	W	12E-0sw	0.068	sw	4.56	0.96	272	242	1103	233	0	0	0	0
	G	VINYL U 34 SHGC	0.340	sw	22.78	22.28	12	3	273	267	0	0	0	0
	G	VINYL U 34 SHGC	0.340	sw	22.78	23.71	18	3	410	427	0	0	0	0
	W	15B13-0wc-8	0.093	sw	2.74	0.00	256	216	591	0	0	0	0	0
	G	VINYL U 34 SHGC	0.340	sw	22.78	26.57	40	0	911	1063	0	0	0	0
	W	12E-0sw	0.068	nw	4.56	0.96	448	388	1768	373	0	0	0	0
	G	VINYL U 34 SHGC	0.340	nw	22.78	21.70	12	0	273	260	0	0	0	0
	G	VINYL U 34 SHGC	0.340	nw	22.78	21.70	18	0	410	391	0	0	0	0
	G	VINYL U 34 SHGC	0.340	nw	22.78	21.70	30	0	683	651	0	0	0	0
	W	15B13-0wc-8	0.093	nw	2.83	0.00	448	388	1097	0	0	0	0	0
	G	VINYL U 34 SHGC	0.340	nw	22.78	21.70	60	0	1367	1302	0	0	0	0
	R	12E-0sw	0.068	-	2.38	1.02	264	243	578	248	0	0	0	0
	D	11A0	0.470	n	16.45	7.05	21	21	345	148	0	0	0	0
	C	16B-0ad	0.408	-	0.00	0.00	462	462	0	0	0	0	0	0
	C	16B-38ad	0.026	-	1.74	1.22	1808	1808	3150	2198	513	513	894	624
	F	20P-0t	0.521	-	0.00	0.00	462	462	0	0	0	0	0	0
	F	20P-30c	0.035	-	2.35	0.24	16	16	38	4	0	0	0	0
	F	21A-32c	0.020	-	1.34	0.00	560	560	750	0	0	0	0	0
	F	21A-32c	0.020	-	1.34	0.00	896	896	1201	0	0	0	0	0
	F	21A-32v	0.020	-	1.34	0.00	336	336	450	0	0	0	0	0
6	c) AED excursion									1816				513
	Envelope loss/gain								21937	11689			3477	2429
12	a) Infiltration								4088	497			1080	131
	b) Room ventilation								0	0			0	0
13	Internal gains:	Occupants @	230				5			1150	0			0
		Appliances @	1200				2			2400	0			0
	Subtotal (lines 6 to 13)								26025	15736			4557	2560
	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								0	0			240	88
14	Subtotal								26025	15736			4798	2649
15	Duct loads						0%	0%	0	0	0%	0%	0	0
	Total room load								26025	15736			4798	2649
	Air required (cfm)								830	995			153	167

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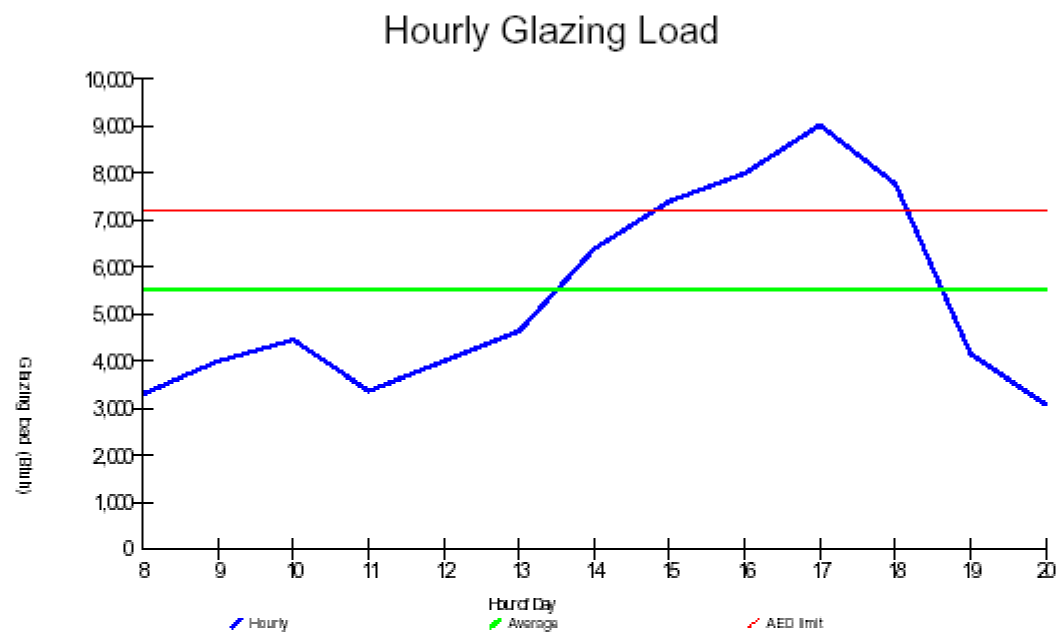
Adequate Exposure Diversity

According to Manual J 8 procedures, a zone is defined as having Adequate Exposure Diversity (AED) if the maximum hourly glazing load (PFG) does not exceed the average glazing load (AFG) by more than 30%. The amount over 30% of the AFG is defined as the AED Excursion.

Test for Adequate Exposure Diversity



Maximum hourly glazing load exceeds average by 62.8%.

House does not have adequate exposure diversity (AED), based on AED limit of 30%.

AED excursion: 1816 Btuh (PFG - 1.3*AFG)

Load calculation questions?

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	**Cooling**
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
GAMA ID	144278	
Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Cooling Equipment Summary

Make	Carrier	
Trade	Base 13 Puron AC	
Cond	24ABA324A30	
Coil	CAP**2414A**++TDR	
ARI ref no.	738723	
Efficiency	11.6 EER, 13 SEER	
Sensible cooling	18148	Btuh
Latent cooling	3203	Btuh
Total cooling	21350	Btuh
Actual air flow	995	cfm
Air flow factor	0.063	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

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Page 1

Equipment Selection
ACCA Manual S
Heating

The required load (Heat Loss) on our example house is 29,891 Btuh.
I have selected a Carrier (No reason but that I had all of the performance specifications) model 58MCB 040-12x. This unit has a 40,000 Btuh input rating and has an efficiency rating of 92.3 AFUE.

The output rating will be about 33,156 Btuh after derating for efficiency and for altitude.

40,000 x .923 = 36,920 x .90 = 33,156 Btuh

So what is the correct adjustment for altitude?? Manual S does have generic deration factors but only if the manufacturer does not provide any deration information. See the footnotes in the performance data.

Per Manual S it is acceptable to size up to 140% the MJ8 required load for gas fired forced air furnace
29,891 x 1.4 = 41,847 > 33,156 Btuh

Performance data

UNIT SIZE		040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20	140-20
CERTIFIED TEMP RISE RANGE (°F)		30—60	15—45	45—75	30—60	20—50	40—70	30—60	20—50	45—75	30—60	40—70	50—80
CERTIFIED EXT STATIC PRESSURE (In. wc)	Heating	0.10	0.10	0.12	0.12	0.12	0.15	0.15	0.15	0.20	0.20	0.20	0.20
	Cooling	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AIRFLOW CFM‡	Heating	850	1125	885	1065	1320	1190	1285	1785	1315	1690	1720	1970
	Cooling	895	1215	900	1200	1545	1245	1525	1925	1570	1930	2000	1990

EFFICIENCY

UNIT SIZE			040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20	140-20
OUTPUT CAPACITY BTUH* (ICS) (Shaded capacities are specified on rating plate)	Direct Vent (2-Pipe)	Upflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
		Downflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
		Horizontal	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	127,000
	Non-Direct Vent (1-Pipe)	Upflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
		Downflow	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
		Horizontal	37,000	37,000	56,000	56,000	56,000	74,000	74,000	74,000	93,000	93,000	112,000	NA
INPUT BTUH†			40.000	40,000	60,000	60,000	60,000	80,000	80,000	80,000	100,000	100,000	120,000	120,000
AFUE% Nonweatherized ICS	Direct Vent (2-Pipe)	Upflow	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3
		Downflow	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2
		Horizontal	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.0
	Non-Direct Vent (1-Pipe)	Upflow	92.1											NA
		Downflow	91.0											NA
		Horizontal	91											NA

* Capacity and AFUE in accordance with U.S. Government DOE test procedures.
† Gas input ratings are certified for elevations to 2000 ft. For elevations above 2000 ft, reduce ratings 2% for each 1000 ft above sea level. In Canada, derate the unit 5% for elevations 2000 to 4500 ft above sea level.
‡ Airflow shown is for bottom only return-air supply. For air delivery above 1800 CFM, see Air Delivery table for other options. A filter is required for each return-air supply.
ICS—Isolated Combustion System

Equipment Selection

Heating

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
GAMA ID	144278

Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Temperature Rise:
The difference in the air temperature entering the heat exchanger and the air leaving the heat exchanger.

Heat (temperature) Rise Formula:

Btuh/cfm/(1.1xACF) = Temperature Rise
Where:
Btuh = Heating output
CFM = Actual Air Flow in Cubic Feet per Minute
1.1 is a formula constant at sea level
ACF = Altitude Correction Factor from Table 10A (5000' = .832)

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Equipment Selection
Heating

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method	Simplified
Construction quality	Average
Fireplaces	0

	Heating	Cooling
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
GAMA ID	144278

Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Actual Air flow is from the manufacturers performance data at a specific static pressure

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Equipment Selection

Heating

Performance data

UNIT SIZE		040-08	040-12	060-08	060-12	060-16	080-12	080-16	080-20	100-16	100-20	120-20
CERTIFIED TEMP RISE RANGE (°F)		30—60	15—45	45—75	30—60	20—50	40—70	30—60	20—50	45—75	30—60	40—70
CERTIFIED EXT STATIC PRESSURE (In. wc)	Heating	0.10	0.10	0.12	0.12	0.12	0.15	0.15	0.15	0.20	0.20	0.20
	Cooling	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AIRFLOW CFM‡	Heating	850	1125	885	1065	1320	1190	1285	1785	1315	1690	1720
	Cooling	895	1215	900	1200	1545	1245	1525	1925	1570	1930	2000

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	760	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1285	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	925	910	850	830	770	705	635
060-08	1 side or bottom	High	1100	1065	1005	945	900	805	730	610
		Med-Low	890	865	810	765	705	620	540	475
		Low	745	710	670	625	565	505	425	360
060-12	1 side or bottom	High	1430	1375	1325	1275	1200	1135	1040	935
		Med-High	1270	1260	1215	1160	1105	1035	950	850
		Med-Low	1070	1055	1045	1015	975	920	850	750
		Low	915	895	885	865	840	800	720	650
060-16	1 side or bottom	High	1700	1695	1640	1580	1545	1450	1380	1310
		Med-High	1500	1465	1435	1385	1355	1300	1250	1185
		Med-Low	1325	1295	1265	1230	1190	1150	1105	1050
		Low	1205	1170	1145	1110	1080	1035	990	950
080-12	1 side or bottom	High	1535	1470	1405	1330	1245	1160	1065	935
		Med-High	1395	1350	1300	1225	1155	1080	985	880
		Med-Low	1200	1175	1125	1065	1030	970	890	780
		Low	1040	1020	990	960	910	860	785	680
	1 side	High	1750	1685	1635	1575	1525	1445	1380	1310
		Med-High	1495	1455	1405	1355	1305	1250	1185	1120

58MCB

Heating Equipment Selection Questions?

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	**Cooling**
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Heating Equipment Summary

Make	Carrier	
Trade	Carrier	
Model	58MCB040-12x	
GAMA ID	144278	
Efficiency	92.1 AFUE	
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Cooling Equipment Summary

Make	Carrier	
Trade	Base 13 Puron AC	
Cond	24ABA324A30	
Coil	CAP**2414A**++TDR	
ARI ref no.	738723	
Efficiency	11.6 EER, 13 SEER	
Sensible cooling	18148	Btuh
Latent cooling	3203	Btuh
Total cooling	21350	Btuh
Actual air flow	995	cfm
Air flow factor	0.063	cfm/Btuh
Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

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Equipment Selection
Cooling

wrightsoft

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Entire House
Gil Rossmiller

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For: Colorado ED Inst. March 2010

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Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

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Static pressure	0.70	in H2O
Load sensible heat ratio	1.00	

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Equipment Selection
Cooling

You will need the detailed cooling capacities to verify proper sizing

DETAILED COOLING CAPACITIES

EVAPORATOR AIR		CONDENSER ENTERING AIR TEMPERATURES deg F												
		75			85			95			105			
CFM	EWB	Capacity MBtuh†		Total System KW**	Capacity MBtuh†		Total System KW**	Capacity MBtuh†		Total System KW**	Capacity MBtuh†		Total System KW**	
		Total	Sens‡		Total	Sens‡		Total	Sens‡		Total	Sens‡		T
24ABA324A30 Outdoor Section With CAP*2414A** Indoor Section														
700	72	27.11	14.29	1.61	25.97	13.86	1.81	24.75	13.40	2.03	23.47	12.92	2.28	22
	67	24.89	17.62	1.61	23.81	17.16	1.81	22.66	16.68	2.03	21.45	16.19	2.28	20
	62	22.86	20.91	1.61	21.86	20.44	1.81	20.81	19.93	2.04	19.72	19.39	2.28	18
	57	22.24	22.24	1.61	21.43	21.43	1.82	20.56	20.56	2.04	19.64	19.64	2.28	18
800	72	27.54	14.98	1.64	26.35	14.54	1.84	25.08	14.08	2.06	23.76	13.60	2.31	22
	67	25.31	18.74	1.64	24.19	18.29	1.85	23.00	17.81	2.07	21.75	17.31	2.31	20
	62	23.37	22.46	1.65	22.36	21.95	1.85	21.35	21.35	2.07	20.38	20.38	2.32	19
	57	23.14	23.14	1.65	22.28	22.28	1.85	21.36	21.36	2.07	20.38	20.38	2.32	19
900	72	27.83	15.64	1.68	26.61	15.19	1.88	25.31	14.72	2.10	23.96	14.25	2.34	22
	67	25.61	19.83	1.68	24.46	19.37	1.88	23.25	18.88	2.10	21.97	18.37	2.35	20
	62	23.85	23.85	1.68	22.96	22.96	1.88	22.00	22.00	2.10	20.98	20.98	2.35	19
	57	23.87	23.87	1.68	22.97	22.97	1.88	22.00	22.00	2.10	20.98	20.98	2.35	19

Multipliers for Determining the Performance With Other Indoor S

Our target loads: Total = 16,613 Btuh Sensible = 16,613 Btuh Latent = 0.00 Btuh

Remember we said that 75° dry bulb at 50% RH is psychometrically equal to 62° wet bulb.
EBW = Entering Wet Bulb temperature. We will use the 62° value
The designer has chosen 800 cfm (We will see if that works)

The air entering the condenser (the outdoor unit) is the outside dry bulb design temperature.
Remember for Denver the outdoor design temperature is 90° dry bulb.
Per Manual S we can be with in 5°. We will use the 95° value.

At first glance this equipment has no latent capacity. Notice the total and sensible capacities are the same at 21,350 Btuh. Now look at the footnote ‡

* Detailed cooling capacities are based on indoor and outdoor unit at the same elevation per ARI standard 210/240−94. If additional tubing length and/or indoor unit is located above outdoor unit, a slight variation in capacity may occur.

** Total system kW is total of indoor and outdoor unit kilowatts.

† Total and sensible capacities are net capacities. Blower motor heat has been subtracted.

‡ Sensible capacities shown are based on 80°F (27°C) entering air at the indoor coil. For sensible capacities at other than 80°F (27°C), deduct 835 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air for each degree below 80°F (27°C), or add 835 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air per degree above 80°F (27°C).
When the required data fall between the published data, interpolation may be performed.

Equipment Selection
Cooling

The designer has chosen 800 cfm. That is about 80% of 1000 cfm, so we will use a deduction of 668 Btuh

Remember our indoor design temperature is 75° not 80°.
So: 80 – 75 = 5 x 668 = 3,340 New sensible capacity is 21,350 – 3,340 = 18,010 Btuh

So we have equipment that looks like this:
Total Capacity = 21,350 Sensible Capacity = 18,010 Btuh Latent Capacity = 3,340 Btuh

SHR = 18,010/21,350 = .84 (Close enough to our target of .85)

Per Manual S we can be up to 15% oversized:
Target total load of 16,613 x 1.15 = 19,104 Btuh < 21,350 Btuh
So this unit is slightly oversized (technically)

Equipment Selection
Cooling

What about the effects of altitude?

If you are moving 1000 cfm at sea level are you moving 1000 cfm at 5000'?

Air at altitude is less dense than air at sea level and therefore you need to move more air at altitude to get the same performance or derate the capacity.

All of the performance data provided by the manufacturers is performance at sea level. Adjustments must be made for performance at altitude. Unfortunately very few if any manufactures provide any guidance for altitude adjustment for air conditioners.
Fortunately Manual S does in appendix 6

The formula for air density correction:
CFM at Altitude = Sea-Level Flow Rate / Density Ratio

The air density correction factor for 5000' is .832
Solve for example house:
800/.832 = 962 cfm

Equipment Selection

Cooling

Now we have determined that our cooling equipment will have the capacity needed at 962 cfm. The question now is will the blower deliver?

Remember earlier we used .7 IWC for heat cfm. It appears if we set the blower at High it will deliver 995 cfm. Works for me!

AIR DELIVERY—CFM (With Filter)*

UNIT SIZE	RETURN-AIR SUPPLY	SPEED	EXTERNAL STATIC PRESSURE (In. wc)							
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
040-08	1 side or bottom	High	1075	1040	995	945	895	840	760	670
		Med-Low	850	825	780	740	685	635	560	480
		Low	740	700	650	620	565	515	455	385
040-12	1 side or bottom	High	1470	1415	1400	1285	1215	1120	995	890
		Med-High	1315	1280	1235	1180	1115	1035	930	825
		Med-Low	1125	1110	1085	1045	990	915	830	740
		Low	930	925	910	850	830	770	705	635
060-08	1 side or bottom	High	1100	1065	1005	945	900	805	730	610
		Med-Low	890	865	810	765	705	620	540	475
		Low	745	710	670	625	565	505	425	360
060-12	1 side or bottom	High	1430	1375	1325	1275	1200	1135	1040	935
		Med-High	1270	1260	1215	1160	1105	1035	950	850
		Med-Low	1070	1055	1045	1015	975	920	850	750
		Low	915	895	885	865	840	800	720	650
060-16	1 side or bottom	High	1700	1695	1640	1580	1545	1450	1380	1310
		Med-High	1500	1465	1435	1385	1355	1300	1250	1185
		Med-Low	1325	1295	1265	1230	1190	1150	1105	1050
		Low	1205	1170	1145	1110	1080	1035	990	950
080-12	1 side or bottom	High	1535	1470	1405	1330	1245	1160	1065	935
		Med-High	1395	1350	1300	1225	1155	1080	985	880
		Med-Low	1200	1175	1125	1065	1030	970	890	780
		Low	1040	1020	990	960	910	860	785	680
[illegible]	1 side	High	1750	1685	1635	1575	1525	1445	1380	1310
		Med-High	1495	1455	1405	1355	1305	1250	1185	1120

58MCB

Cooling Equipment Selection QUESTIONS?

wrightsoft

Project Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

Notes:

Design Information

Weather: Denver, CO, US

Winter Design Conditions

Outside db	3	°F
Inside db	70	°F
Design TD	67	°F

Summer Design Conditions

Outside db	90	°F
Inside db	75	°F
Design TD	15	°F
Daily range	H	
Relative humidity	50	%
Moisture difference	-36	gr/lb

Heating Summary

Structure	26025	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	3867	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	29891	Btuh

Infiltration

Method		Simplified
Construction quality		Average
Fireplaces		0
	Heating	**Cooling**
Area (ft²)	3600	3600
Volume (ft³)	14464	14464
Air changes/hour	0.28	0.15
Equiv. AVF (cfm)	67	36

Sensible Cooling Equipment Load Sizing

Structure	15736	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	877	Btuh
Blower	0	Btuh
Use manufacturer's data	y	
Rate/swing multiplier	1.00	
Equipment sensible load	16613	Btuh

Latent Cooling Equipment Load Sizing

Structure	274	Btuh
Ducts	0	Btuh
Central vent (64 cfm)	-1281	Btuh
Equipment latent load	0	Btuh
Equipment total load	16613	Btuh
Req. total capacity at 0.85 SHR	1.6	ton

Heating Equipment Summary

Make	Carrier
Trade	Carrier
Model	58MCB040-12x
GAMA ID	144278

Efficiency	92.1	AFUE
Heating input	40000	Btuh
Heating output	33156	Btuh
Temperature rise	44	°F
Actual air flow	830	cfm
Air flow factor	0.032	cfm/Btuh
Static pressure	0.70	in H2O
Space thermostat		

Cooling Equipment Summary

Make	Carrier	
Trade	Base 13 Puron AC	
Cond	24ABA324A30	
Coil	CAP**2414A**++TDR	
ARI ref no.	738723	
Efficiency	11.6 EER, 13 SEER	
Sensible cooling	18148	Btuh
Latent cooling	3203	Btuh
Total cooling	21350	Btuh
Actual air flow	995	cfm
Air flow factor	0.063	cfm/Btuh
Static pressure	0.70	in H2O
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Manual D
Duct Sizing

Now that we have determined the house loads and selected the proper sized equipment, how do make certain the needed cfm is delivered to each room????

Manual D provides us with design parameters and calculations that will result in a duct system that will provide adequate air flows to rooms. Not designing your ductwork at this stage can have disastrous results like:

- Undersized ductwork effects furnace temperature rise (to high)
- Undersized ductwork effects cooling capacity (freezing coil)
- Equipment efficiency is lessened – more energy is used and comfort levels go down
- Unacceptable noise levels

Manual D requires that the duct system be equipped with balancing dampers. Manual D will get you close but is not perfect. Some duct over sizing will occur; with balancing dampers the flow can be adjusted.
How many contractors actually use balancing dampers one their systems??
In my experience very few, this is not a bad thing but the builder may have some comfort issues.

Steps in duct design:

1. Determine cfm flow to each room

2. Make a rough sketch of duct runs- supplies and returns
   I encourage designers to do this on the framing plan to avoid structural members.

3. Collect information on blower and all air side pressure drops.
   This would be the coil, air filters, registers and grills.

4. Determine the total equivalent length of the duct work.
   This is the longest supply path plus the longest return path.
   Don't forget the fittings.

5. Determine the friction rate. You will need to know available static pressure.

6. Size all ductwork based on needed flow and friction rate.

See how easy it is!!!!

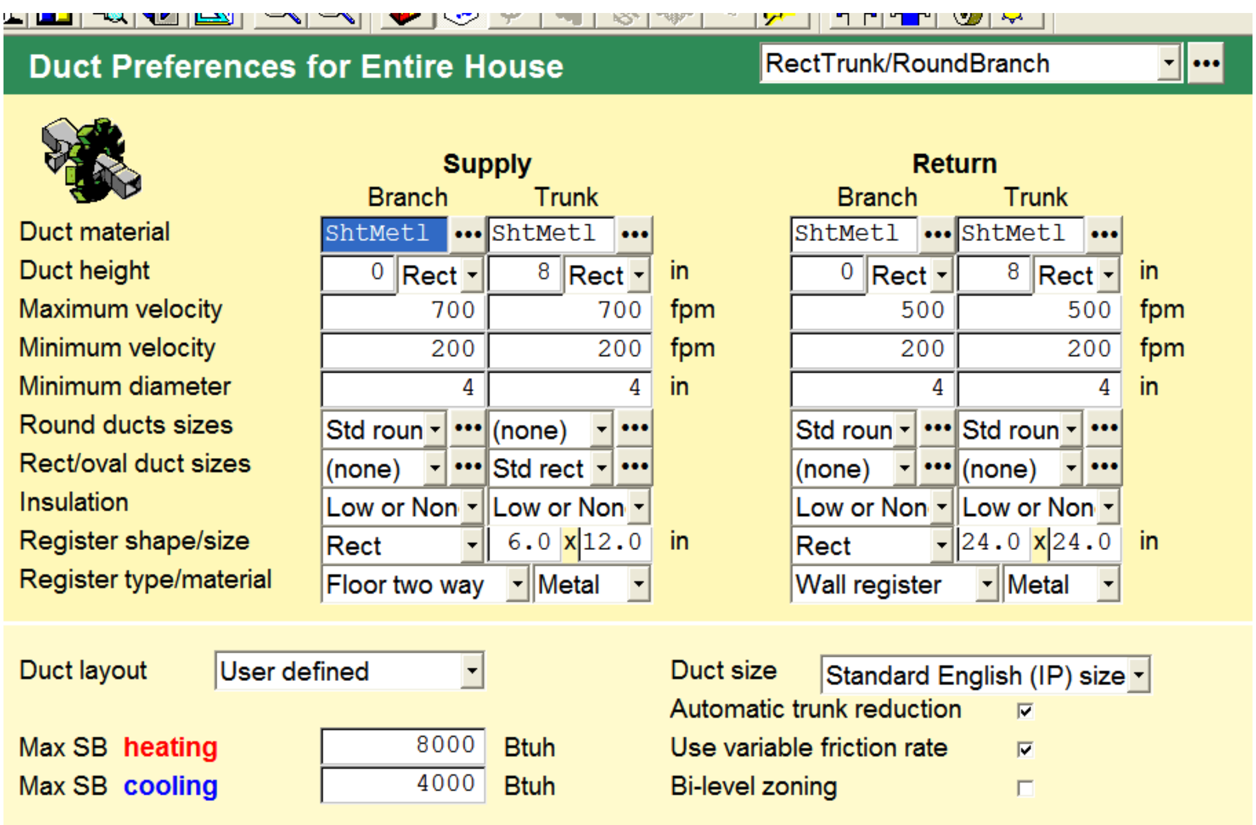
Manual D
Duct Sizing

A reasonably well designed system will be within these parameters:

1. Total system flow will be ± 5% of design flow.
2. Room flows will be ± 10% of design flow. (I have allowed ± 20%)
3. Total system static will be ± 0.10 IWC of design.
4. Duct velocities are within Manual D recommendations.

Recommended Velocities (FPM)								
	Supply Side				Return Side			
	Recommended		Maximum		Recommended		Maximum	
	Rigid	Flex	Rigid	Flex	Rigid	Flex	Rigid	Flex
Trunk Ducts	700	600	900	700	600	600	700	700
Branch Ducts	600	600	900	700	400	400	700	700
Supply Outlet Face Velocity	Size for throw		700		-------		--------	
Return Grille Face Velocity	--------		--------		-------		500	
Filter Grille Face Velocity	--------		---------		-------		300	

Copy of Table 3-1 from ACCA Manual D



Manual D

Duct Sizing

The required cfm to each room is relative to the rooms calculated load. Essentially if the room requires 5% of the equipments capacity the room will need 5% of the blower cfm.

To determine the required cfm per room you must calculate the heating and cooling factors.
(Wrightsoft labels this as ‘Air Flow Factor’)

- Heating Factor = Blower Cfm ⁄ MJ8 Heat Loss (for structure)
- Cooling Factor = Blower Cfm ⁄ MJ8 Sensible Load (for structure)

Solve for today’s house

- Heating Factor = 830 ⁄ 26,026 = .032
- Cooling Factor = 995 ⁄ 15,736 = .063

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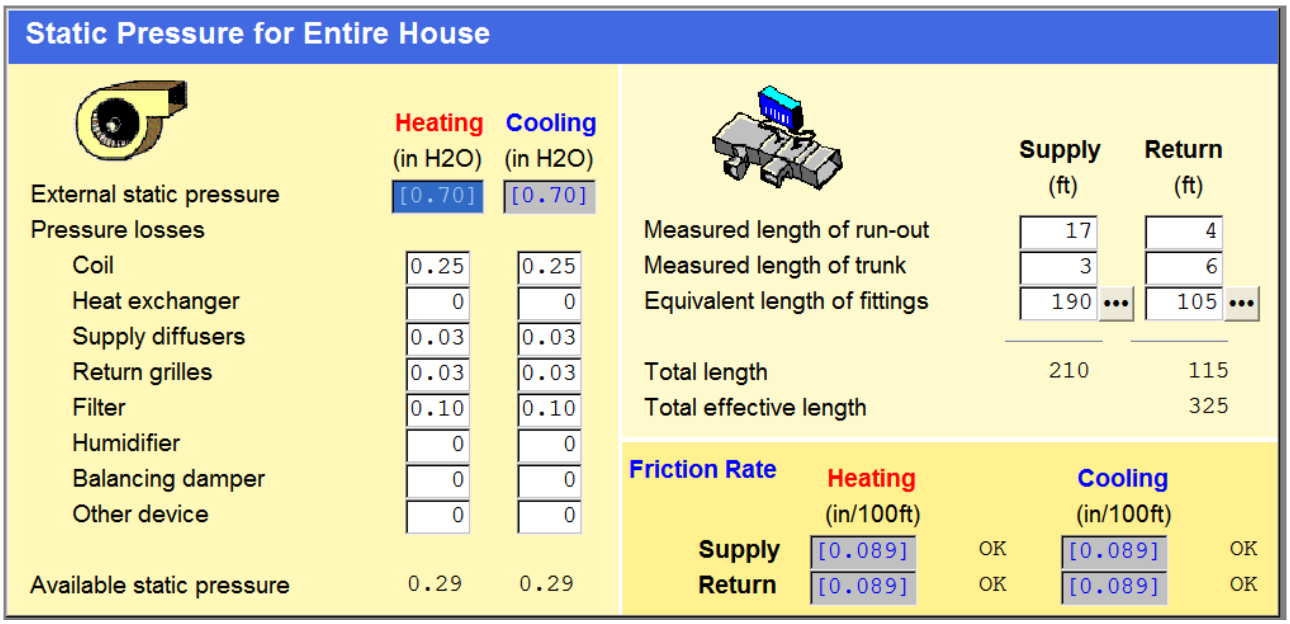
Manual D
Duct Sizing

The Wrightsoft program does most of the work for you. The proper inputs are critical.

Determine your available static pressure:

1. Start with the static pressure you used for the equipment. Remember we used .7 IWC.
2. Enter the AC coil resistance. This found in the manufactures performance data.
3. Enter heat exchanger resistance. Ours was included with the performance data.
4. Enter supply registers and return grille resistance. We will use .03 IWC.
5. Enter filter resistance. Most performance data includes 'cost effective' filter.
6. Enter humidifier resistance, from manufactures performance data.
7. Enter balancing dampers if used.
8. Any other devices like air cleaners etc.



This is the friction rate formula: ASP x 100/TEL

Where:

ASP = Available static pressure

100 = The friction rate is per 100' of duct length

TEL = Total Equivalent Length of ductwork

Solve:

.29 x 100/325 = .089

Per Manual D the friction rate must be not less than 0.06 and not more than 0.18.

Manual D
Duct Sizing

wrightsoft

Duct System Summary
Entire House
Gil Rossmiller

Job:
Date: Feb 2010
By: Gil Rossmiller

Project Information

For: Colorado ED Inst. March 2010

	Heating		Cooling	
External static pressure	0.70	in H2O	0.70	in H2O
Pressure losses	0.41	in H2O	0.41	in H2O
Available static pressure	0.29	in H2O	0.29	in H2O
Supply / return available pressure	0.19 / 0.10	in H2O	0.19 / 0.10	in H2O
Lowest friction rate	0.089	in/100ft	0.089	in/100ft
Actual air flow	830	cfm	995	cfm
Total effective length (TEL)		325 ft		

Supply Branch Detail Table

Name		Design (Btuh)	Htg (cfm)	Clg (cfm)	Design FR	Diam (in)	H x W (in)	Duct Matl	Actual Ln (ft)	Ftg.Eqv Ln (ft)	Trunk
Bed 1-A	c	1412	67	89	0.104	6.0	0x0	ShMt	20.0	160.0	st1A
Bed 3	c	839	50	53	0.096	5.0	0x0	ShMt	40.0	155.0	st2A
Bed 4	h	1419	45	45	0.108	4.0	0x0	ShMt	28.0	145.0	st2
Dining	c	1076	34	34	0.095	4.0	0x0	ShMt	32.0	165.0	st2B
Kitchen	c	1724	49	109	0.097	6.0	0x0	ShMt	44.0	150.0	st2A
Kitchen-A	c	1724	49	109	0.092	6.0	0x0	ShMt	39.0	165.0	st2B
Laundry	h	639	20	18	0.112	4.0	0x0	ShMt	17.0	150.0	st1
Living-A	c	1324	77	84	0.115	5.0	0x0	ShMt	18.0	145.0	st2
Living-B	c	1324	77	84	0.110	5.0	0x0	ShMt	31.0	140.0	st2
Master Bedroom	c	1301	65	82	0.109	5.0	0x0	ShMt	27.0	145.0	st1
Master Bedroom-A	c	1301	65	82	0.116	5.0	0x0	ShMt	17.0	145.0	st1
Mst. Bath	c	673	39	43	0.089	4.0	0x0	ShMt	20.0	190.0	st2
Recreation	c	859	53	54	0.116	5.0	0x0	ShMt	22.0	140.0	st1
Recreation-A	c	859	53	54	0.112	5.0	0x0	ShMt	17.0	150.0	st2
Recreation-B	c	859	53	54	0.104	5.0	0x0	ShMt	21.0	160.0	st1A
Storage/Furnace	h	1081	34	0	0.100	4.0	0x0	ShMt	7.0	180.0	st2

Manual D

Duct Sizing

Duct preferences for today's house

Fitting Preferences

Elbows

Metal	Rect supp	8B3
	Round supp	8AE
	Rect ret	8B3
	Round ret	8AE
Flex		11I

Takeoffs

Supply	Rect	2H1
	Round	2J0
Return	Rect	6B1
	Round	6C3

Boots

Supply	4AD
Return	6M

Flex Junctions

3 ducts	11M
> 3 ducts	11A

Trunk Junction Fittings

Supply	Rect trunk	Rect br	9L
		Rnd br	9A1
	Round trunk		9I1
Return	Rect branch		10A
	Round branch		10G

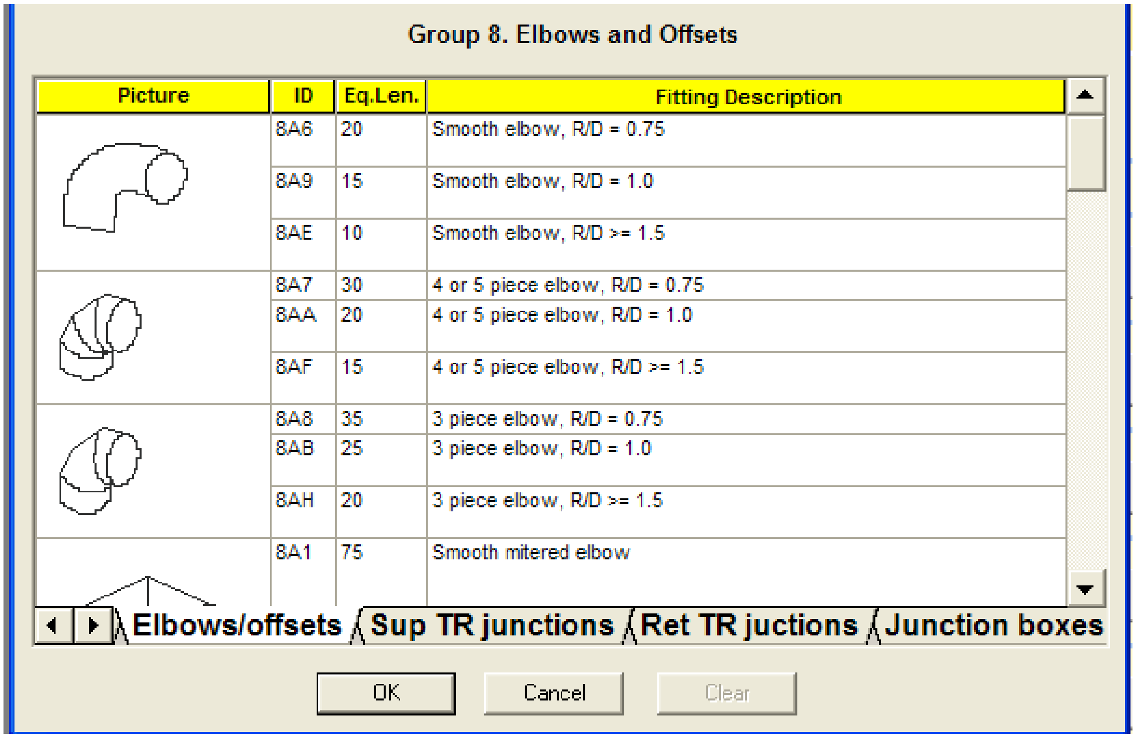
Transitions

Supply	Rect	12C1
	Round	12A1
Return	Rect	12F1
	Round	12D1

Fan Fittings

Supply	Rect	1P
	Round	1A
Return	Rect	5K
	Round	5D

Manual D
Duct Sizing

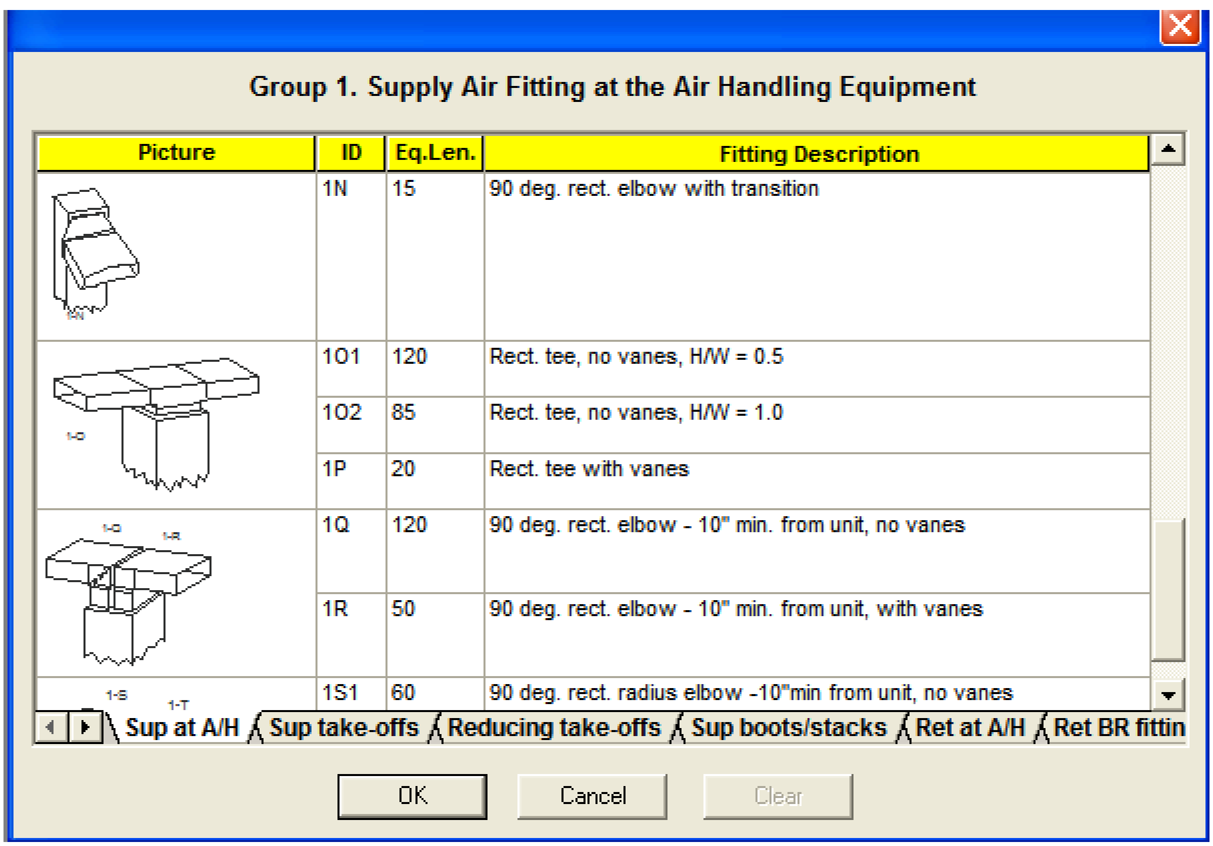


Group 8. Elbows and Offsets

Picture	ID	Eq.Len.	Fitting Description
	8A6	20	Smooth elbow, R/D = 0.75
	8A9	15	Smooth elbow, R/D = 1.0
	8AE	10	Smooth elbow, R/D >= 1.5
	8A7	30	4 or 5 piece elbow, R/D = 0.75
	8AA	20	4 or 5 piece elbow, R/D = 1.0
	8AF	15	4 or 5 piece elbow, R/D >= 1.5
	8A8	35	3 piece elbow, R/D = 0.75
	8AB	25	3 piece elbow, R/D = 1.0
	8AH	20	3 piece elbow, R/D >= 1.5
	8A1	75	Smooth mitered elbow

Elbows/offsets | Sup TR junctions | Ret TR juctions | Junction boxes

OK Cancel Clear



Group 1. Supply Air Fitting at the Air Handling Equipment

Picture	ID	Eq.Len.	Fitting Description
	1N	15	90 deg. rect. elbow with transition
	1O1	120	Rect. tee, no vanes, H/W = 0.5
	1O2	85	Rect. tee, no vanes, H/W = 1.0
	1P	20	Rect. tee with vanes
	1Q	120	90 deg. rect. elbow - 10" min. from unit, no vanes
	1R	50	90 deg. rect. elbow - 10" min. from unit, with vanes
	1S1	60	90 deg. rect. radius elbow -10"min from unit, no vanes

Sup at A/H | Sup take-offs | Reducing take-offs | Sup boots/stacks | Ret at A/H | Ret BR fittin

OK Cancel Clear

Manual D
Duct Sizing

Group 5. Return Air Fittings at the Air Handling Equipment

Picture	ID	Eq.Len.	Fitting Description
	5H2	30	Square elbow, H/W = 2.0
	5I1	45	Mitered inside corner elbow, H/W = 1.0
	5I2	30	Mitered inside corner elbow, H/W = 2.0
	5J1	20	Radius elbow, R/W = 0.25
	5J2	15	Radius elbow, R/W = 0.50
	5J3	10	Radius elbow, R/W = 1.00
	5K	10	Square elbow with vanes
	5L	75	Rect. tee, no vanes
	5M	10	Rect. tee with vanes

Sup boots/stacks | Ret at A/H | Ret BR fittings | Ret joists/studs | Elbows/offsets | Sup TR ju

OK | Cancel | Clear

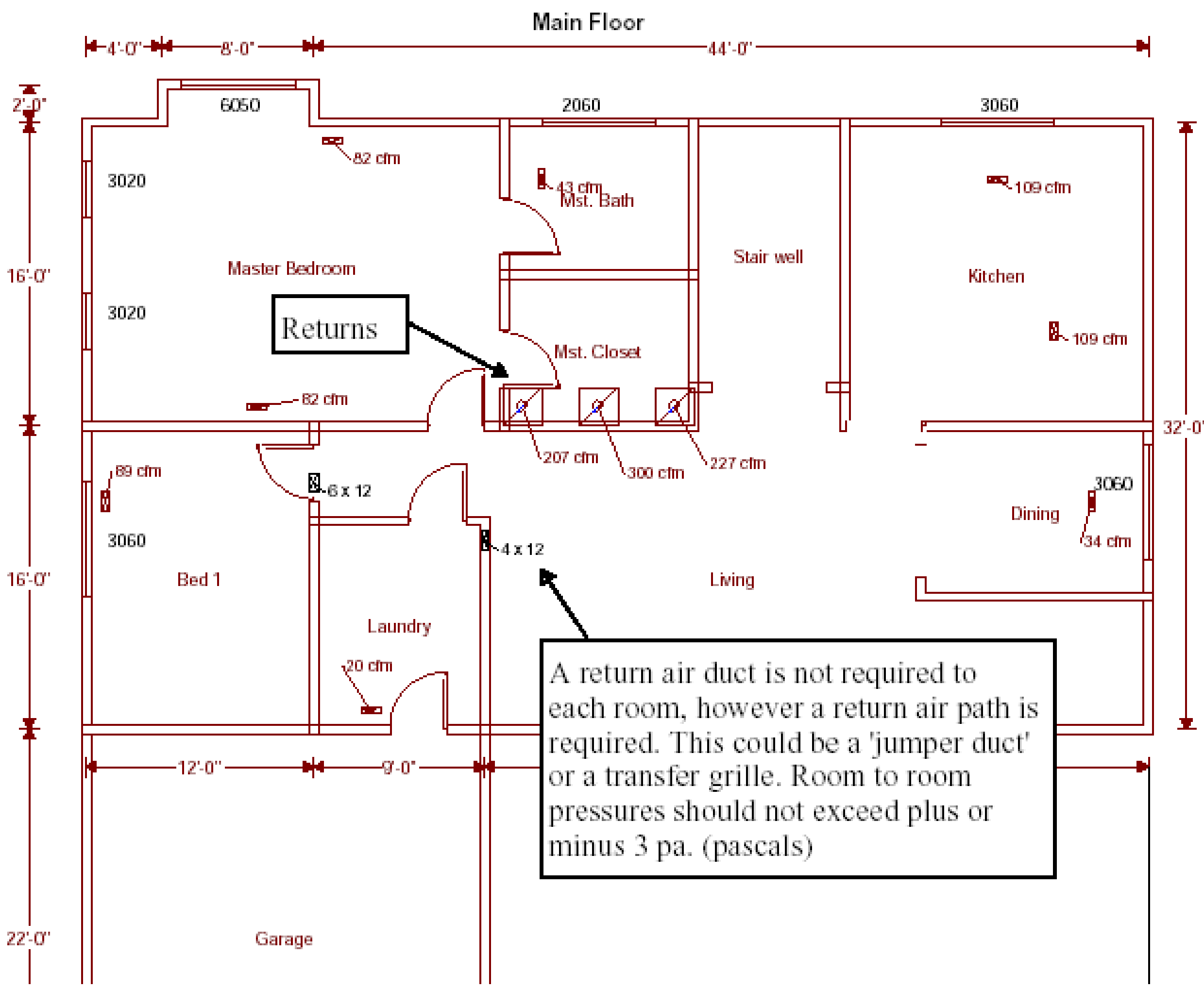
Group 2. Branch Take-Off Fittings at the Supply Trunk

Picture	ID	Eq.Len.	Fitting Description
	2H4	85	Rect. from side with scoop, 4 dstr.br
	2H5	95	Rect. from side with scoop, 5 or more br
	2I0	65	Round from top, no transition, 0 dstr.br
	2I1	75	Round from top, no transition, 1 dstr.br
	2I2	85	Round from top, no transition, 2 dstr.br
	2I3	95	Round from top, no transition, 3 dstr.br
	2I4	100	Round from top, no transition, 4 dstr.br
	2I5	110	Round from top, no transition, 5 or more br
	2J0	50	Round from top with round transition, 0 dstr.br
	2J1	60	Round from top with round transition, 1 dstr.br
	2J2	65	Round from top with round transition, 2 dstr.br
	2J3	70	Round from top with round transition, 3 dstr.br
	2J4	75	Round from top with round transition, 4 dstr.br
	2J5	80	Round from top with round transition, 5 or more br
	2K0	50	Round from top with rect. transition, 0 dstr.br
	2K1	60	Round from top with rect. transition, 1 dstr.br
	2K2	65	Round from top with rect. transition, 2 dstr.br

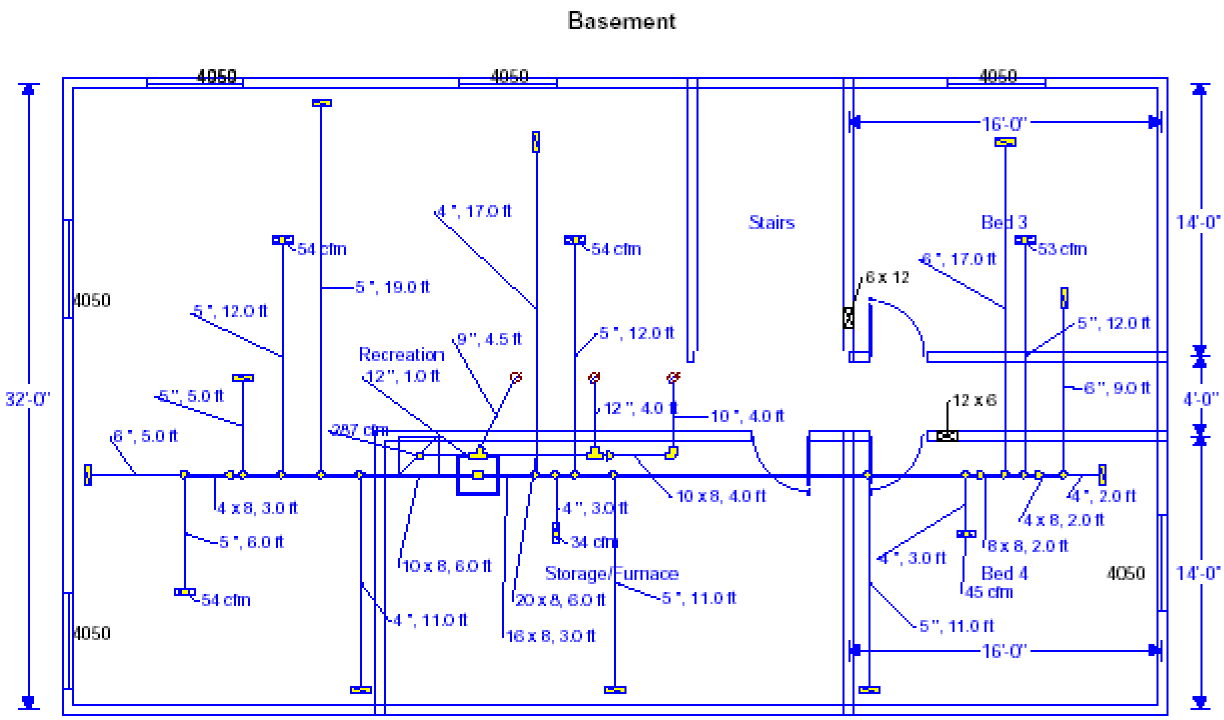
Sup at A/H | Sup take-offs | Reducing take-offs | Sup boots/stacks | Ret at A/H | Ret BR fittin

OK | Cancel | Clear

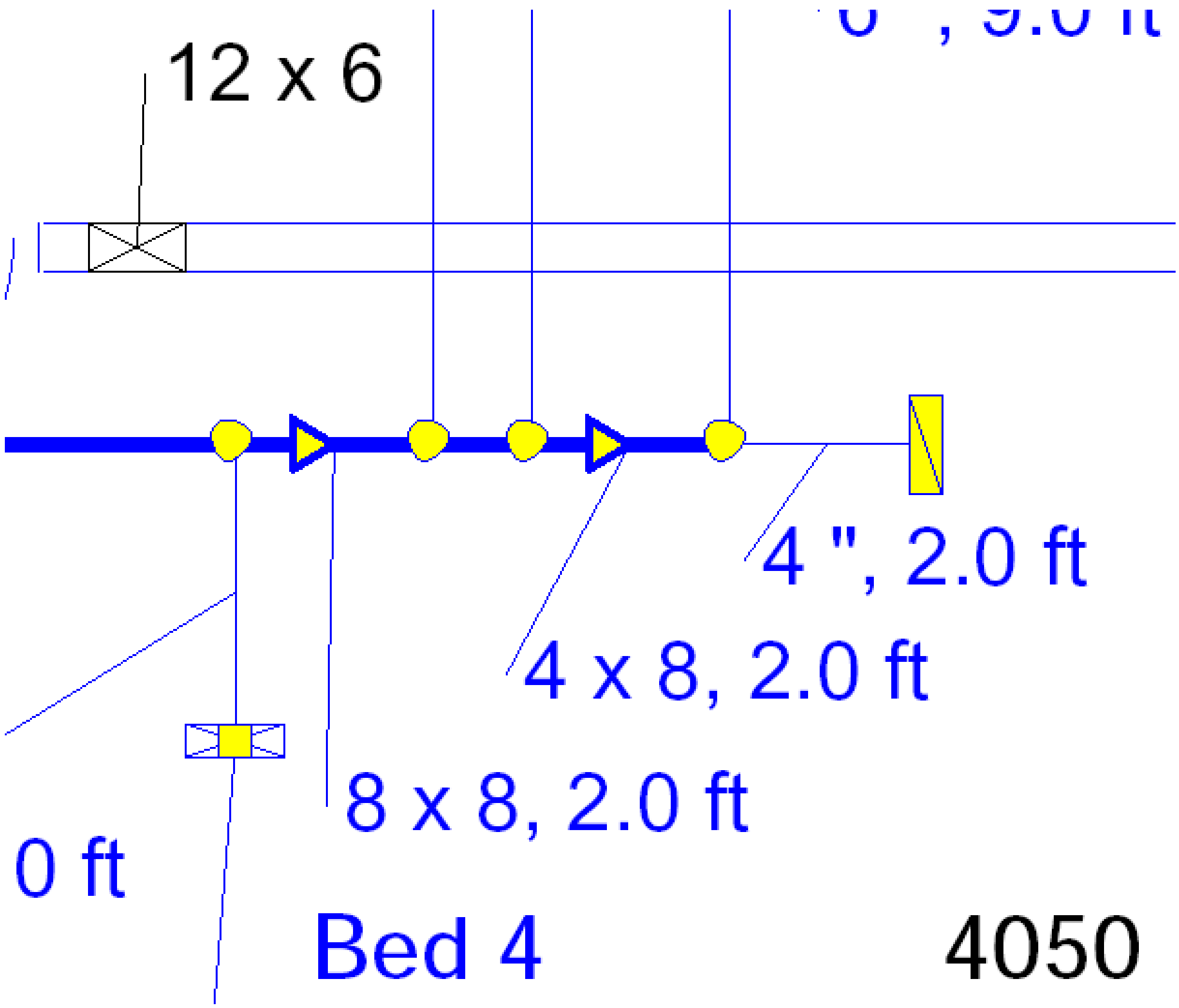
Today’s House



Manual D
Duct Sizing
Today's House



Manual D
Duct Sizing



System Verification with Testing

Now that the designers have done their job it is now up to the builder and the trade contractors.

Contractor		Date
Subdivision		
Address	Lot	

Rough Duct Leakage

Duct Leakage		Pass	Fail
Leakage Maximum			

Rough Pressures & Flows

Static Pressure	yes	no		
Coil Present				
Filter Removed				
Cooling Speed				
Return Pressure				
Supply Pressure				
Total Static Pressure		Pa.	Pass	Fail
Maximum Static Pressure				
Air Cycler	low	high		
Measured Flow			Pass	Fail
Design Air Flow				
Air Flow For Cooling	low	high		
Design Air Flow			Pass	Fail
Total Supply Measured Air Flow				

Final Commissioning

Air Flow			Pass	Fail
All Rooms +-20% of Design				
All Rooms <3Pa.				
Heating				
Return Air Temp				
Supply Air Temp				
Furnace Heatrise			Pass	Fail
Furnace Heatrise Range				
Air Conditioning				
Condenser Air Entering Temp				
Target Subcooling from Mfg.		<12 SEER=10		
Liquid Line Temp		12SEER =15		
High Side Temp (from gauge chart)			Pass	Fail
Actual Subcooling		3 degrees from target?		
Structural Floor Exhaust Fan	low	high		
Measured Flow			Pass	Fail
Design Air Flow				

Contact Information:

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